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ABSTRACT

This publication examines the causes and effects of poor indoor air quality and provides information for reducing exposure to indoor contaminants in schools. It discusses the various indoor pollutants found in schools, including dust, chemical agents, gases, and volatile organic compounds; where they are found in schools; and their health effects on school occupants. Pollution control measures are detailed in the areas of building design, product specifications, renovation procedures, operations and maintenance, and ventilation system management. (Contains 15 references.) (GR)

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Managing Indoor Air Quality in Schools

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May 2000

According to the Environmental Protection Agency (EPA), the concentration of pollutants indoors can be two to five times greater than outdoor environments. Research at the Air Pollution Health Effects Laboratory at the University of California at Irvine indicates that children are six times more vulnerable to indoor air contaminants than adults due to faster respiration rates and lower body weights. IAQ Publications Online indicates that poor indoor air quality (IAQ) may aggravate asthma and allergic diseases, which affect 20 percent of all school-aged children. According to the U.S. General Accounting Office 1995 report, *Condition of America's Schools*, 19 percent of U.S. elementary and secondary schools suffer from indoor air quality problems, and 36 percent report "less-than-adequate" heating, ventilating and air conditioning (HVAC) systems (U.S. GAO 1995:14–15).

Recognizing and managing indoor air quality problems is an important part of providing a healthy and safe school that optimizes student learning. Failure to prevent or quickly resolve problems can (U.S. Environmental Protection Agency 1995:3):

- increase the potential for short-term and long-term health problems,
- reduce the productivity of children, teachers, and staff,
- accelerate deterioration and reduce the efficiency of HVAC equipment,
- strain relationships among school administration, parents, and staff, and
- create potential liability problems.

This publication is an introduction to the causes and effects of poor indoor air quality and provides information for reducing exposure to indoor contaminants in schools.

Identifying Pollutants and Their Effects

Here is an overview of indoor pollutants, where they are found in schools, and their health effects on school occupants.

Dust and Fibers

Dust is made up of particles generated from dirt, pollen, pet dander, and lead-based paint and from burning oil, coal, and wood emissions.

Asbestos is a natural fiber that is a good insulator and is fire and corrosion resistant. In older schools, asbestos can be found in 9"x 9" flooring tiles, ceiling tiles, plaster, corrugated pipe insulation, spray-on acoustical soundproofing, spray-on thermal insulation and fireproofing, fire doors, stage light wiring, and roofing and siding shingles. Fiberglass, another good insulator, is found in thermal insulation and duct linings; when disturbed its fibers become airborne.

Breathing dust and fibers can cause shortness of breath, chest pain, fatigue, weakness, and headaches. Exposure to lead dust can cause damage to the nervous system, high blood pressure, anemia, stunted growth, learning difficulties, behavior problems, and short-term memory loss. Inhaling particles released when asbestos products are disturbed can cause lung infection and cancer.

Chemical Agents

Pesticides such as acaricide are used against mites, herbicides prevent weeds, insecticides eliminate insects, and rodenticides are used against mice and rats.

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Cleansers, solvents, and strippers that contain bleach, ammonia, ethanol, methanol, isopropyl, methyl ethyl ketone (MEK), acetone, xylene, phenol, benzene, styrene, toluene, and lye are used for maintenance purposes.

Deodorizers and disinfectants contain phenol, formaldehyde, cresol, glycols, methylene chloride, and dichlorobenzene.

Cosmetics, including perfumes, colognes, nail polish, nail polish remover, hair spray and aftershave lotions, contain formaldehyde and toluene.

The possible effects of breathing pesticides, cleansers, deodorizers, disinfectants, and cosmetics are headaches, nausea, weakness, dizziness, numbness, memory loss, and eye, nose and throat irritations. Exposure to pesticides, cleansers, deodorizers, and disinfectants may also cause cancer and liver, kidney, pancreas, spleen, and central nervous system damage.

Biological Pollutants

Mold and mildew are fungi that thrive in areas with high humidity or standing water. Contamination is usually associated with HVAC systems that are improperly maintained or with water damage from leaking roofs, walls, and windows. Bacteria and viruses also flourish in areas with high humidity and moisture problems.

Allergens include dust mites, insect parts and wastes, pollen, and pet dander collected in carpeting, drapes, and upholstered furniture.

Health risks associated with biological pollutants include asthma, allergic rhinitis (hay fever), respiratory diseases, and legionnaire's disease.

Gases

Carbon monoxide, carbon dioxide, nitrogen oxide, and sulfur dioxide are gases produced by combustion sources such as furnaces, gas heaters, gas stoves, kilns, and automobiles. Radon is an invisible radioactive gas that is emitted from granite, shale and phosphate rocks. It can enter schools by way of dirt floors, openings around drains and sump pumps, spaces between pipes and walls or floors, and cracks in floors, walls, and foundations.

Breathing carbon monoxide, carbon dioxide, nitrogen oxide, and sulfur dioxide can cause headaches, dizziness, weakness, nausea, confusion and disorientation, impaired vision, angina, asthma, emphysema, chronic bronchitis, lung cancer, and death. Chronic exposure to elevated radon levels has been linked to an increased incidence of lung cancer.

Volatile Organic Compounds (VOCs)

Volatile organic compounds are chemicals that vaporize or "off-gas" at normal room temperatures. Formaldehyde, a colorless chemical compound with a strong odor, can be found in the adhesive or glue in manufactured wood products such as particleboard, plywood, fiberboard, paneling, cabinets, and furniture; as a preservative in some paints and sealants; as a coating on upholstery, drapes, carpets, and paper products; and in urea-formaldehyde foam and fiberglass insulation. Sources of combustion such as burning wood, kerosene, natural gas, and cigarettes also emit formaldehyde into the air.

Other VOCs include acetone, butyl and isopropyl (emitted from cleaners and tobacco smoke), aromatic hydrocarbons (from adhesives, sealants, caulking, gasoline, paint, pesticides, solvents, resilient flooring, and tobacco smoke), benzene (produced by combustion processes, gasoline, solvents, and tobacco smoke), chlorinated hydrocarbons (from wood preservatives and solvents) phenols (from furnishings and tobacco smoke), and styrene (from carpeting).

Exposure to VOCs can cause eye irritations, sinus problems, breathing difficulties, coughing, sore throat, chest pain, wheezing, skin irritations, nausea, drowsiness, fatigue, central nervous system damage, and liver, kidney, and heart problems.

Managing Indoor Air Quality

The two integral components of a healthy indoor school environment are controlling pollution sources and providing an appropriate HVAC system. Pollution control can be achieved through careful consideration of building design, product specifications, renovation procedures, and operations and maintenance procedures. Ventilation system variables are air temperature, relative humidity, air movement, and air filtration.

Design

Indoor air quality issues need to be considered in the site selection and building design phases of a school project to avoid costly corrections later.

When selecting a school site, address the following:

- proximity to fumes and noise at industrial sites, freeways, airports, railroads, and garbage incinerators,
- proximity to dust and pesticides from agricultural areas,
- possible environmental hazards such as radon, hazardous wastes, and underground storage tanks, and
- drainage that can divert water from the site.

The design of the building envelope is important to assure good indoor air quality.

- Consider climate factors, such as temperature and prevailing winds, when designing the building elevations and layout.
- Pitched roofs are preferred by some because they reduce the possibility of standing water and snow and ice build-up.
- Properly design and install vapor barriers to prevent condensation that causes moisture problems.
- Locate parking, bus and car drop-off points, and loading docks away from air intake vents to prevent exhaust fumes from being drawn into the building.

The layout and design of the interior spaces in a school also contribute to providing a healthy environment.

- Prevent dirt from entering the building. New York's High Performance Building Guidelines suggests using the following: textured paving for outside approaches, recessed metal gratings in vestibules, and "walk-off" mats in entryways (City of New York Department of Design and Construction 1999:125).
- Vent art rooms, photography labs, painting studios, pottery kilns, automotive and machine workshops, science laboratories, pet areas, cooking areas, custodial storage closets, copy rooms, and restrooms directly to the outdoors to prevent their pollutants from being recirculated throughout the school's HVAC system. Locate these vents away from fresh air intake vents.
- Design restrooms with proper drainage to prevent standing water in sinks or on floors. Suspend stall partitions, toilets, and sinks to allow for thorough floor cleaning (City of New York Department of Design and Construction 1999:125)

Product Specification

New products or materials should be evaluated for emissions characteristics, life cycle duration, and toxicity.

Composite wood furniture and cabinets, paneling, room dividers, drapery, paints, and flooring have a high probability of containing VOCs; select lower emitting products when available. Whenever new products with the potential for off-gassing are installed, allow adequate time for off-gassing before reoccupying the area and increase ventilation with outdoor air (U.S. Environmental Protection Agency 1998:1).

Select a low-VOC emitting paint that is free of lead and mercury. Schedule painting to occur when the area is unoccupied and allow time for paint odors to dissipate before occupants return to the area. Operate the HVAC system continuously (24 hours a day), at the highest possible outdoor air supply setting, from the beginning of the painting work until several days after painting has been completed.

Hard flooring, such as terrazzo, ceramic tile, and brick, is durable and easy to clean. Hardwood flooring is preferable to laminate flooring, which contains formaldehyde. For a less expensive alternative, specify linoleum (with a linseed oil base) or vinyl composition tile, which are less volatile than sheet vinyl (Miller 1995:178–180).

When using carpeting for acoustical and safety reasons, select low-VOC emitting carpet, carpet cushion/pad, and adhesive. Make sure the carpet does not contain liquid latex or a vinyl backing. If the carpet supplier is unable to provide testing and emissions data on the carpet being considered, contact the Carpet and Rug Institute (*www.carpet-rug.com*). Unroll flooring products and cushion in a well-ventilated location prior to installation. Install carpet only when the school building is not in use. Operate the HVAC system at normal temperature and highest possible outdoor air supply setting during installation and for at least 72 hours after installation is completed. Do not install carpet near water fountains, sinks, showers, pools or other water sources (U.S. Environmental Protection Agency 1998:5)

Renovation

When undertaking a school renovation project, it is important to evaluate the potential hazards of demolition.

- Inspect the building to determine if it contains

asbestos products, lead paint, or excessive amounts of mold and mildew.

- Hire professionals and take special precautions when removing and disposing of hazardous materials.

- Whenever possible, schedule renovation and major repair projects when the building is unoccupied, such as on weekends, holidays, and vacations. When that is not possible, take special care to minimize the dust, fumes, and noise associated with the renovation.

- Use plastic sheeting, portable fans, and a mechanical ventilation strategy, as appropriate, to prevent dust and fumes from reaching school occupants through hallways, doors, windows, and the HVAC system.

- Beware of cutting off a room from its supply of outdoor air, enclosing a pollutant source (like photocopiers) in a room with inadequate exhaust or supply air, or erecting barriers that prevent adequate movement of air throughout the occupied area of a room (U.S. Environmental Protection Agency 1998:1–2).

- Provide a separate source of ventilation for the area under construction.

- If necessary, temporarily relocate school occupants.

Operations and Maintenance

Implementing the following practices in operations and maintenance functions will help maintain a healthy indoor environment.

- Control dust and dirt with damp mops or vacuum cleaners that have high efficiency particle air (HEPA) filters. Dusters should not be used.

- Eliminate or limit the use of toxic and harmful chemicals. Avoid using products with strong odors.

- Use soap and water or low-emission cleansers as cleaning agents. Choose cleansers that have been evaluated and certified by Green Seal (*www.greenseal.org*) or Scientific Certification Systems (*www.scs1.com*).

- Avoid toxic deodorizers; baking soda is a good alternative.

- Control moisture. When shampooing carpets, avoid overwetting and allow sufficient time for thorough drying. Remove water damaged ceiling tiles and carpeting immediately and provide extra ventilation in areas with high humidity.

- Do not treat carpets with chemical cleaners, pesticides, or deodorizers.

- Seal cracks in foundations and slabs to prevent radon contamination.

- Implement integrated pest management (IPM) at all schools. Major components of IPM include: identifying pests; establishing regular inspections for pests; determining health and aesthetic tolerances to pest populations; preventing pest problems through sanitation, physical barriers, and environmental modifications; and selecting the least hazardous pesticides for targeted area only when non-chemical measures have failed. Additional information on IPM is available from the University of Florida's School IPM web site, *www.ifas.ufl.edu/~schoolipm/*.

- Run HVAC systems whenever the school building is occupied. Begin their operation at least one or two hours before school is reopened to flush out accumulated pollutants (U.S. Environmental Protection Agency 1998:videotape)

- Proper training of staff and occupants is crucial to long-term success.

Ventilation

The proper design and maintenance of ventilation systems is necessary to provide good indoor air quality. New schools are beginning to use HVAC systems capable of introducing proper amounts of outside air to dilute internal contaminants. Engineers are recognizing the importance of providing schools with the same air quality standards that are applied in commercial office buildings (Seyffer 1999:55).

Ventilation systems need to maintain the appropriate temperature and humidity level. Comfortable temperature ranges vary according to heating and cooling seasons as well as occupancy. For elementary schools, temperature settings should be 70 degrees for heating and 78 degrees for cooling. At the secondary school level the heating settings should be slightly lower, 65 to 68 degrees with the cooling settings remaining the same at 78 degrees (Anne Arundel County Public Schools 1989:17). Humidity levels in schools should range from 25 to 35 percent for cool periods to 50 to 60 percent for warm periods. Relative humidity levels below 20 percent are uncomfortable to most people and should be avoided.

Humidity levels above 70 percent increase mold and dust mite growth, decay, and corrosion (Miller 1995:84–85).

The design of these systems must provide good air distribution and air flow in and out of the building. Follow the recommendations of the American Society of Heating Refrigerating and Air Conditioning Engineers' ASHRAE Standard 62-1989, Ventilation for Acceptable Air Quality.

Filters in the HVAC system remove airborne contaminants such as bacteria, mold, pollen, smoke, and dust. ASHRAE Standard 52.1-1992, Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter, provides information on filter efficiencies. Filters rated for at least 30 percent dust spot efficiency are recommended (Quraishi 1999:48). Testing procedures for evaluating the performance of air-cleaning devices as a function of particle size are available in ASHRAE Standard 52.2-1999, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

New HVAC systems should be commissioned (tested) by a third party to determine that all systems are working as specified. Recommissioning is recommended every 4 to 5 years to ensure that all systems are operating at the design levels.

The proper maintenance and repair of HVAC systems is necessary to provide good indoor air. Air intake vents must be kept free of debris and obstructions at all times so the appropriate amount of air can enter the unit. Filters must be changed on schedule; clogged filters will cause a pressure drop in the system. Coils, fans, interior housings, and ductwork should remain free of dust and dirt. Periodic checks should be made to ensure that controls and dampers are operating correctly. Check for sources of standing water in condensation drip pans and areas around ventilation systems regularly, since standing water provides a breeding ground for bacteria and fungus.

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More information about indoor air quality is available online at *www.edfacilities.org/ir/iaq.cfm*.

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The U.S. Environmental Protection Agency. *Sources for Information on Indoor Air Quality* and *IAQ Tools for Schools Action Kit are* available online at www.epa.gov/iedweb00/schools or from the Indoor Air Quality Information Clearinghouse, P.O. Box 37133, Washington, D.C. 20013-7133; phone: (800) 438-4318 or (703) 356-4020.

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Additional Information

See the NCEF Hot Topic *Indoor Air Quality*, online at www.edfacilities.org/ir/iaq.cfm

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